Proposed title of the thesis:

Integrated Watershed Management: A Study of Dwarka River Basin, Eastern India

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Introduction

A watershed is the area which drains to a common outlet. Degradation of watersheds brings the long-term reduction of the quantity and quality of water, land and allied resources. Changes in watersheds are the results of a variety of natural and anthropogenic factors, namely, unscientific use and excessive misuse of water, soil erosion, changes in farming systems, overgrazing, deforestation, pollution and so on. The combination of environmental costs and socio-economic impacts has prompted investment in watershed management in many developed and developing countries. Integrated Watershed Management (IWM) aims at the optimum and integrated use of water, land, flora and fauna in a geographically discrete drainage area for the gain of its residents, with the objective of conserving all the resources of that watershed.

Concept of a Watershed

Before going to IWM in details, one should focus on the concept of watershed. A watershed is an area of land that captures rainfall and other precipitation and funnels it to a lake or stream or wetland. Each river drains through an area of land called its drainage basin – also known as its catchment or watershed – which supplies water and sediment to the channel. This area is bounded by a drainage divide or catchment boundary, something that is clearly visible as a ridge in mountainous areas but which can be rather difficult to discern in areas of more subdued topography (Charlton, 2007).

Relevance of watershed studies

Watershed study is of much relevance for some causes. First of all, if one wants to study the status, potentials, vulnerability of natural resources on the basis of resource consumption or wants to compare natural resource regions for determining more suitable resource utilisation framework or scheme; he/she needs physical or natural territorial units, preferably homogeneous in nature. In reality, the concept of homogeneous physical unit, to be more precise, is a vague one because each place is unique in its own way. But if a watershed is being studied as a whole, it enables a holistic study of each and every element that is embedded in that particular watershed. So, 'Watershed' is a term which in a sense defines homogeneity of a physical unit.

Secondly, Identification of correlation between and among the components of a watershed is very important for tracing the short and long term impact of resource utilisation on man and environment. Multitalented genius Leonardo da Vinchi once said, "... everything connects to everything else." The connection among the components of watershed and the degree of interdependence of those components can be revealed through watershed studies. For instance, if a researcher only investigates the problem of transportation of any place and suggests constructing a bridge there; he/she may not get the expected result as he/she does not take into account the geology underneath, soil quality of that place etc.

Concept of Integrated Watershed Management

In general sense, Integrated Watershed Management (IWM) means management of all the resources available in a particular hydro-territorial unit, i.e., watershed. The deterioration of natural resources of an area in this manner can be contained and accordingly development can be done of agricultural lands, the barren hill slopes and the stream beds, and all the resources of the area- water, fuel, fodder, livestock, fish and the most important one, the human resources, in a harmonious way. This involves the exploration and development of the complex inter-relationships between the watershed resources and its living population (Narayana, Sastry & Patnaik, 1990). Therefore, Water Resource Management (WRM), River Basin Management (RBM), Flood Management (FM) etc are integral part of IWM.

Location of the Study Area

A river basin is a natural unit for integrated water resources planning and management, since water interacts with and to a large degree controls the extent of other natural components such as soil, vegetation, and wildlife (Cai, McKinney & Lasdon, 2003). For the present research purpose Dwarka River Basin (DRB) has been selected. Latitudinal extension of the basin is 23º57'43.905" North to 24º29'27.685" North and longitudinal extension is 87º17'39.515"East to 88º10'36.061" East. The administrative status of the basin area is shown in the following table.

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Name of States	Name of Districts	Name of C. D. Blocks
Jharkhand	Pakur	Maheshpur, Pakuria, Amrapara
	Godda	Sundarpahari
	Dumka	Gopikandar, Kathikund, Ramgarh, Dumka, Shikaripara, Ranishwar
West Bengal	Birbhum	Murarai II, Nalhati I, Nalhati II, Rampurhat I, Rampurhat II, Mayureshwar I, Md. Bazar
	Murshidabad	Raghunathganj I, Sagardighi, Nabagram, Khargram, Kandi

Justification of the Study Area

1. On an average, 72.61 % working people are engaged in agriculture and allied fields (Census of India, 2011). So, agriculture is the dominant economic activity. In the study area, the percentage of Gross Cropped area to total area of the C D Block is 38.52%. In the study area, irrigation is provided to only 21.65 % of the gross cropped area (District Census Handbook, Birbhum, Murshidabad and Dumka 2011). Few field visits revealed that condition of water availability through irrigation is even worse than the official records. Water is the most important input for agriculture. This area also shows a mixed picture of rainfall deficiency and excessive rainfall. Physical attributes like land, soil etc cannot be changed and water is a major need for agriculture. So, in this area water availability status has to be checked and if there is any problem regarding its availability suitable water management strategy should be chalked out.
2. The area comes under the command area of Mayurakshi Canal Irrigation Project which has now lost its importance (Ghosh, 2014). It has imposed adverse affects on the fluvial dynamics and micro geomorphic features of the command area. This is true for all mega irrigation projects. Predominantly because of standard principles of dam building are irrespective of the finer nuances of the local physical attributes. Besides, mega irrigation projects demand continuous monitoring and upkeep the cost which is never headed to lead to their non functionality with time. Hence, the study focuses on the traditional techniques to conserve and recharge ground water along with the modern methods, up to a sustainable level, within the framework of socio- cultural setup of the basin area, maintaining also the ecological balance.
3. As stated earlier, source of usable water and sustainable management of available resource are contemporary issues. Several research works are going on in global level. In national level, although, this type of works is in practice, but, till date, micro watershed level comprehensive studies on this issue are meagre in Dwarka river basin. Dwarka river is one of the major tributaries of Brahmani river. As per the previous literature, few works on flood dynamics (Let, 2012) have been found so far. Therefore, the area has been chosen to initiate watershed management study there.

Objectives

Objectives of the research paper are given below-

1. To assess the existing problems regarding the status of availability of water for irrigation and domestic use.
2. To find out ground water potentiality; ground water recharge zone and suitable discharge zone of Dwarka River Basin.
3. To assess the soil erosion of the basin and divide the basin into iso-erosion zones.
4. To assess the economic and ecological viability of the land use pattern focusing on the land capability classification.
5. To suggest some alternative strategies, based on both modern and indigenous practices, of water resource management, soil conservation and agricultural development for self sufficiency.
6. To explain the need of people's participation in grass root level watershed management planning.

Importance of the present study

The motto of any research work is to go deep into any problem and find out effective ways for mitigation. In the present context the problem taken to be studied is how the optimum utilisation of locally available resource is possible by means of watershed management. For example: management of available water resource is equally important in both the water scant areas and water surplus areas. The western part of DRB has low availability of water unlike its eastward extension. The researcher will try to find out a way to decrease the impact of such natural disparity by the application of hydro-geological and geomorphological knowledge. A

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comparative study can be done among the contrasting parts of the basin area based on the water characteristics, site suitability of water harvesting structures and assessment of existing water management system should be attempted. This thesis will also focus on the importance of the people's participation and application of traditional knowledge in the grass root level planning.

Database

Database is very important for conducting any type of research. In this study data have been from both primary and secondary sources.

1. **Primary Sources of Data:** Primary data have been collected directly from the field through conducting field survey. Primary data also have been collected from questionnaire survey for perception study regarding different aspects of water resource management.
2. **Secondary Sources of Data:** Secondary data have been collected from various departments and authorities, like Directorate of Irrigation and Waterways, Govt. of West Bengal, District Census Handbook of Dumka, Birbhum. Burdwan and Murshidabad, District Gazetteer of Dumka, Birbhum, Burdwan and Murshidabad, different blocks of Birbhum, Burdwan and Murshidabad, Geological Survey of India, Central Ground Water Board, State Water Investigation department etc. Topgraphical sheets (published by Survey of India) and LISS III, LISS IV images (published by ISRO) consultation have also been done for secondary data.

Methods

The following methods should be adopted-

1. An outline of the whole work should be prepared.
2. Literature survey, topographical sheet and image consultation should have been done.
3. Demarcation of study area should be done.
4. Mapping of micro topographic features based on slope characteristics is to be attempted.
5. Existing surface water bodies (Ponds, wells, rivers etc.) are to be identified followed by the identification of potential surface water bodies (paleo-channels, wetlands, topographic and structural depressions) that can be used to store excess water to use in dry post monsoon periods.
6. The field has to be visited for several times.
7. The literary facts will be verified in the field according to different parameter, considering pre-field work.
8. According to chosen parameters different data is to be collected with the help of sample survey.
9. The collected data should be processed & represented through suitable cartographic techniques and then Data analysis & map interpretation should be carried out.
10. Temporal changes of land use and land cover will be identified with the help of topographical maps, LISS III and LISS IV satellite imageries and Google Earth.
11. Water potential, soil erosion status, agricultural scenarios and related issues of the basin area are to be assessed, and watershed management strategies should be carried out.
12. Softwares that to be used in this work are Arc GIS 10.0, Erdas Imagine, Paint.Net, MS Paint, MS Office Excel, Minitab and MS Office Word.

Literature Review

Few examples of literature review have been given:-

Literatures Related to Morphometric Analysis and Fluvial Geometry

Hickin (1974) has taken into consideration the problem of interpreting the meander growth pattern from the surface configuaration of flood plain. He has also developed some principles of meander formation in Beatton River in North-East British Columbia. Finally, he has invited extensive field investigation for checking the general applicability of those principles.

Williams (1986) has used an enlarged data set to compare measured meander geometry to that predicted by the Langbein and Leopold (1966) theory, examine the frequency distribution of the ratio radius of curvature/channel width, and derive 40 empirical equations involving meander and channel size features.

Ozdemir & Deanne (2009) have indicated that systematic analysis of morphometric parameters of drainage networks derived from different sources (Topographical sheet and Digital Elevation Model) can afford considerable value in understanding sub basins' drainage characteristics with respect to flooding.

Das (2016) have identified some morphometric diversity in Dwarka River Basin. From such diversity comes the conclusion that probability of soil erosion is high in the upper catchment. It is noticeably low in the lower catchment. Lower catchment is also characterised by enhanced deposition and high water availability.

Literature to Surface Water& Ground Water

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Santra and Mitra Santra (2009) have analyzed the quality and distribution of water resource, both surface and sub surface, of Rupnarayan-Dwarkeshwar basin. To overcome water scarcity in their area of study they suggested constructing dams, contour trenching and bunding, gully plugging measures etc which will help to conserve water, soil moisture and ground water recharge.

Das and Mukhopadhyay (2010) have focused on the status and changing trend of ponds in Kopai river basin. They have found that the actual environmental crisis regarding pond is the deterioration of the water quality and the dearth of maintenance considering its impact on neighbouring society. They have strongly mentioned the importance of increasing the water retention capacity of ponds along with the physical rehabilitation of small tank systems through institutional reforms.

Dutta & Mistri (2013) have addressed the unstable situation of water resources of Barddhaman Municipality, West Bengal. Demand for of water in this municipality is much higher than the amount of actual water supply. This situation is going to be more chronic in future. Therefore, the authors have suggested some management plan based on micro level empirical investigation.

Nag & Das (2014) have assessed the groundwater quality of Suri I and II Blocks of Birbhum District, West Bengal for its irrigational and domestic use purposes. The quantitative chemical analysis results show that most of the water samples are moderately hard in nature with exceptions of a few hard to very hard types.

Literatures Related to Watershed and Water Resource Management

Owen(1968) has proposed an artificial ground water recharge strategy through reclaimation of wastewater. The use of water reclaimed from domestic waste can best be incorporated into a water supply utilizing ground water. A ground water system permits extensive filtration and removal of virus by natural soil chemistry. With proper reclamation equipments and technology the water quantity and quality requirements are possible to meet.

Boers and Ben-Ashers (1982) have reviewed literature on rainwater harvesting and its potential application for crop production published between 1970 and 1980. The review clearly shows that Run off Farming Water Harvesting (RFWH) can be useful in improving irrigation water availability in surface reservoirs. For modelling RFWH, the Unit Hydrograph Method is suitable. More research is required to determine the potential of runoff farming without surface reservoirs.

Cai, McKinney & Lasdon (2003) have described the development and application of an integrated hydrologic-agronomic-economic model to irrigation dominated river basins. The main advantage of the model is its ability to reflect the interrelationships between these components and to explore both economic and environmental consequences of policy choices.

Panhalkar (2010) has detected the priority regions for water management with the help of WERM model. He recommends obligation of roof top harvesting in water scarce regions, practice of contour cultivation, bench terracing, graded bunding, afforestation, grass land management, construction of percolation tank, check dams etc to solve the problem of water scarcity both for drinking and irrigation purpose.

Rawat (2011) has tried to bring together geomorphological and ecological materials that have value in environmental and watershed management for sustainable development.

Mollah (2013) has emphasised on the role of reservoirs on flood analysing the function of Massanjore Dam and DVC. She has suggested that improvement of the maintenance of existing flood infrastructure is needed rather than spending money on new dams and embankments.

Sharidhar (2014) has given suggestions on different methods of artificial groundwater recharging (construction of contour bunds, contour trenches, percolation tanks, village tanks, riverside trenches, afforestation and horticulture etc.) with reference to topographic and geological aspects of Kulhan Nala basin, Raipur, Madhya Pradesh.

Literature related to Human Impact on Physical Attributes

Let and Pal (2010) have highlighted the hydrological modification of Dwarka River due to human interference in the form of unnecessary barrage construction, poor embankment, unwise brick kiln industry location, channel capturing by built up areas. All these collectively intensify flood situation.

Roy (2013) has compared upstream and downstream reaches of Kunur River where the State Highway-14 crossed the river over a bridge. Construction of such road crossing is responsible for aggradation in upstream channel and degradation in downstream channel which are the causes behind frequent flooding and reduction in pier's structural stability of the bridge respectively.

Ghosh & Guchhait (2013) have tried to investigate the pre-dam and post-dam hydrogeomorphic variability in relation to flood risk and limitations of Damodar Valley Multipurpose Project. This project focused on controlling the river dynamics; not on making use of the flood water and sediment in the feasible way. So, its long-term sustainability is questionable. The authors have suggested different thinking and alternatives for using flood water with the combination of wise drainage engineering and traditional knowledge.

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Dinda (2014) has studied that Kolaghat Thermal Power Plant, situated in the right bank of Rupnarayan river, is responsible for reducing depth of that river over years. Proper treatment of waste water before disposal to the river is the only trustworthy way to avoiding such problem.

Literature related to agriculture

Rao (1968) has stated that small farmers used less HYV seeds, fertilizers, farm implements and improved practices than the medium and large farmers.

Ghosh (2011) has established relationship between Hydro-Morphometry and Agricultural Condition of Birbhum district. The western fringe of the district especially the South Western blocks, where the drainage elements and morphometric parameters are high, the agricultural status is poor. Therefore, agricultural planning should be done keeping based on the hydro-morphometric pattern to make the landscape economically feasible.

Mukhoadhyay (2013) has found that undulating terrain, haphazard distribution and fluctuation of rainfall, derelict tanks due to soil erosion, low literacy and technological backwardness, limited irrigation facilities, lack of transport facilities etc. are some major hurdles in the way of agricultural development of Birbhum district and she suggested some strategies for solution.

Aminuzzaman (2014) has found that frequent incidence of flooding results into damage in agriculture system of Murshidabad. The district is affected by frequent flooding, drainage congestion and bank erosion, resulting in extensive submergence of land, loss of life and property and interruption of the communication system.

Literatures Related to Geographic Information System

Knox & Weatherfield (1999) have claimed that GIS- based solutions have been fruitfully developed and applied to a variety of irrigation water resource problems. Further developments and application of integrated GIS approaches can provide solutions for many other emerging water resource problems at local, regional and national levels, and may turn into the preferred environment for irrigation modelling.

Kumar and Reshmidevi (2013) have given brief overview of the potential application of remote sensing in water resource studies in terms of Water resources mapping, Estimation of the hydro-meteorological state variables and fluxes and Applications of the remote sensing data in water resources management.

AbdelRahman, Natarajan, & Hegde (2016) have developed a GIS based approach for land use suitability assessment which will help land managers and land use planners to spot areas with physical constraints for a range of land uses.

Parveen, Kumar, & Singh (2012) have attempted to evaluate the drainage morphometry of Upper South Koel Basin by means of Remote Sensing and GIS approach. Interpretation of satellite images can help in defining lithological and geomorphic units. GIS helps in analysing of various morphometric parameters and acts as a useful tool in establishing relationship between drainage morphometry and landforms. The study also reveals that DEM is very useful in studying the topography within GIS environment.

Tentative Chapterization:

Chapter 1: Introduction to the theme of research

I. Introduction
II. Concept of watershed
III. Relevance of watershed studies
IV. Concept of watershed management

Chapter 2: Introduction to the study

I. Introduction
II. Location and selection of the study area
III. Importance of the study
IV. Objectives
V. Database and Methodology
VI. Review of literature
VII. Limitations

Chapter 3: Geographic background of Dwarka river basin

I. Introduction
II. Geology
III. Physiography
IV. Basin characteristics
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VI. Climate
VII. Hydrology
VIII. Soil
IX. Natural vegetation
X. Land use and land cover
XI. Socio-economic characteristics

Chapter 4: Ground and surface water resource and related issues

I. Introduction
II. Occurrence and movement of ground water
III. Ground water quality
IV. Present scenario of ground water consumption
V. Surface Water Resource
VI. Indigenous and Contemporary Irrigation System
VII. Flood dynamics

Chapter 5: Soil resource and related issues

I. Introduction
II. Soil Erosion Analysis
III. Demarcation of iso-erosion zones

Chapter 6: Land Use- Land Cover and related issues

I. Introduction
II. Temporal Changes of Land Use Land Cover
III. Land Capability Classification
IV. Land use and Land cover justification

Chapter 7: Selected case studies

Chapter 8: Watershed management strategies

I. Introduction
II. Policy Level
III. Field Level
IV. Proposed Watershed Management Strategies

Chapter 9: Conclusion and Future research directions

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